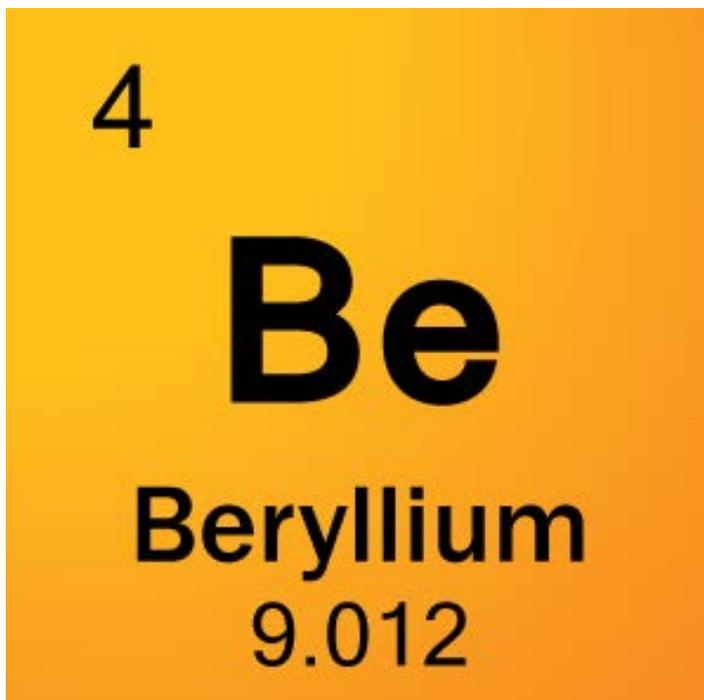


C_002 – Beryllium Safety Training



Kenneth L. Marshall
LLE Chemical Hygiene Officer

Repeated exposure to beryllium particulates can have serious health consequences

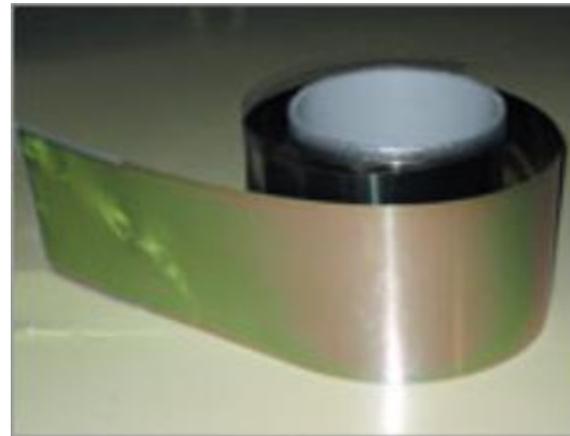


- Health risks from a single-incident exposure to beryllium particles are low and reversible
- **Repeated** exposure to low levels of beryllium *particles* is a risk factor for developing *Chronic Beryllium Disease (CBD) and cancer*
- LLE Instruction 6706 establishes procedures and protocols for working safely with beryllium at LLE
- Both airborne and surface beryllium contamination must be controlled to prevent spread of contamination and potential adverse health effects
- Special precautions must be taken in processing, storage and transport of beryllium-contaminated items within LLE

Procedures in place ensure that potential health risks from working with beryllium at LLE are exceedingly low

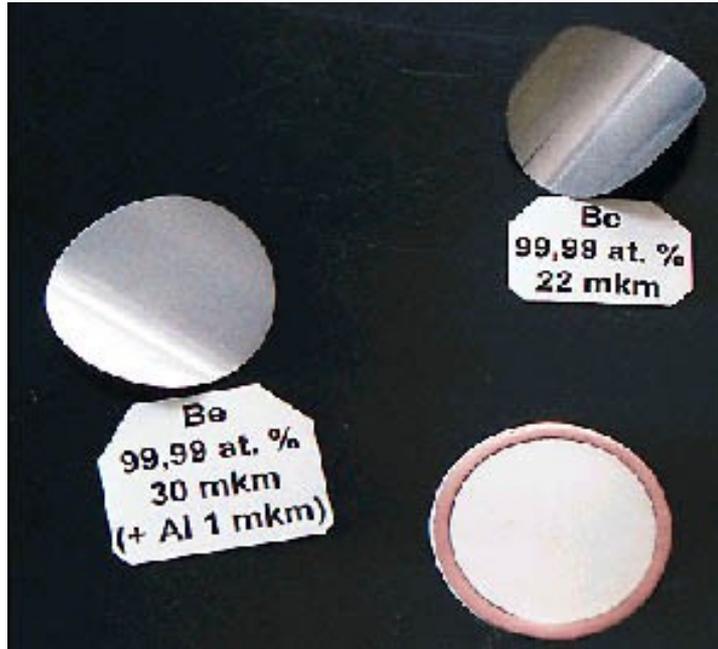
Origins and Properties

- **Beryllium is found in a number of naturally occurring ores and minerals, including emeralds**
- 
- **Beryllium is the lightest element of the “alkaline earth” metals (Group IIA) in the periodic table**
 - discovered by French chemist Louis-Nicolas Vauquelin in 1798, it was originally named “glucinium” because of its “sweet taste”
 - **Physical properties include:**
 - hard, brittle, and light
 - high heat capacity
 - density: 1.8 g/cc
 - melting pt: 1287 °C
 - boiling pt: 2500 °C (est)
 - low x-ray absorption



Ultra-thin beryllium foil

Beryllium plays a vital role in the Inertial Confinement Fusion (ICF) experimental program



Source: http://www.inp.kz/structure/scientific-and-technical-departments/solid-state-physics/laboratory-of-ion-plasma-technology/thin-foils?set_language=en

- Vacuum windows
- X-ray blast filters
- Blast shields
- Target supports
- Diagnostic components

Long term exposure to low concentrations of beryllium particles poses significant health risks

Health risks from a single-incident exposure to beryllium in any form are both relatively low and reversible



- **Acute beryllium disease (ABD)** can develop after a short-term, acute exposure (greater than 100 ug/m³)* to beryllium particulates

ABD forms	Symptoms	Recovery time	Prognosis
Contact dermatitis	Itching, redness, rashes	2-3 weeks	Full recovery
Nasopharyngitis	Pain and swelling in nostrils, nosebleed	4-6 weeks	Full recovery
Tracheobronchitis	Coughing, chest tightness and discomfort	1 month	Full recovery
Pneumonitis	Same as tracheobronchitis plus: <ul style="list-style-type: none"> • poor appetite • weight loss • general fatigue • weakness 	6 months	Fatal cases are rare: full recovery is the norm

Source : Canadian Centre for Occupational Health & Safety

Source : National Library of Medicine Hazardous Substances Data Bank

... but repeated exposure to low levels of beryllium particles presents a risk factor for developing Chronic Beryllium Disease (CBD)



CBD: an *irreversible* lung disease produced by a sensitization (allergic) reaction to beryllium particles

CBD symptoms

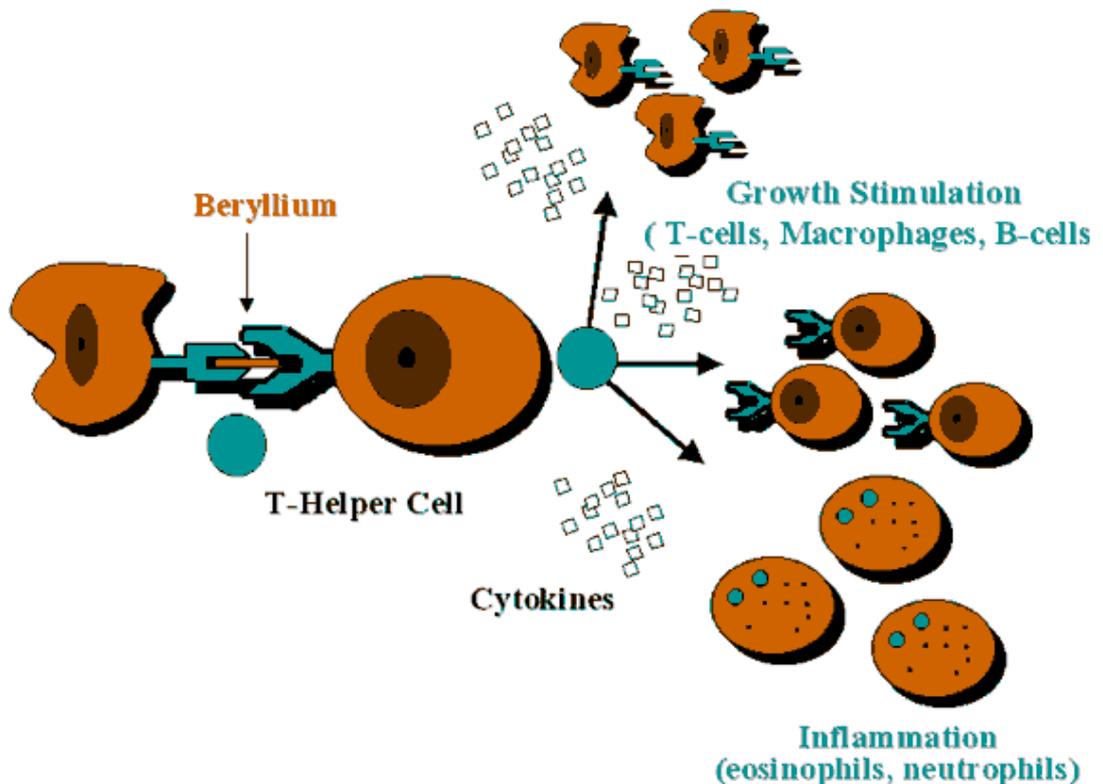
- Shortness of breath with physical activity
- Persistent dry cough
- Fatigue
- Night sweats
- Chest and joint pain
- Loss of appetite
- Incidence level: 1-3%
- Latency period for symptoms: 10 -15 years or longer
- Approximately 17% of individuals with ABD eventually develop CBD¹

Beryllium dust has been determined to cause lung cancer in humans

¹Source: US Beryllium Case Registry (est 1952)

CBD is triggered when respiratory cells recognize beryllium as a foreign particle and initiate an immune response normally used to fight infection

- Activation of T-helper cells in the lung lead to release of cytokines and other immune system activating substances
- Activation causes immune cell proliferation, recruitment of other immune cells to the site of activation, and inflammation
- Chronic activation can lead to permanent scarring of the lung and loss of respiratory capacity



LLEINST 6706* establishes procedures, protocols, and responsibilities for working safely with beryllium



- **Defines accepted safe levels for both airborne and surface beryllium particulate concentrations and contamination level verification protocols**
- **Mandates an “*action level*” in airborne Be particulate contamination requiring implementation of contamination control and personnel protection procedures**
- **Designates work area classification by potential airborne and surface beryllium particulate concentration**
- **Establishes procedures for handling and processing beryllium, and its use**
- **Provides guidance on storage, labeling and disposal of new, in-use and “scrap” beryllium**

*Based on DOE’s Chronic Beryllium Disease Prevention Program (CBDPP)

LLEINST 6706 identifies the maximum allowable exposure limits for surface and airborne beryllium particulates in various work areas at LLE

Area	Contamination type	DOE/LLE Limits
General Areas ¹ : (Uncontrolled)	Airborne (8hr TWA*) <small>*Time Weighted Average</small>	<0.2µg/m ³ (LLE: <0.1 µg/m ³)*
	Removable (surface)	<0.2 µg/100 cm ²
Operational Areas ² :	Airborne (8hr TWA)	<0.2 µg/m ³
	Removable (surface)	<3 µg/100 cm ²
Regulated areas ³ :	Airborne (8hr TWA)	<0.2 µg/m ³
	Removable (surface)	<3 µg/100 cm ²

- ¹ - non-lab areas such as offices and hallways
- ² - areas where workers are routinely in the presence of beryllium as a part of their normal work activities
- ³ - areas in which the airborne concentration of beryllium either exceeds or can be reasonably expected to exceed the action level (i.e. Target chamber, vacuum spaces)

All LLE limits are equal to or below* the DOE Chronic Beryllium Disease Prevention Program (CBDPP) limits

Surface swipe and airborne sampling are routinely performed to ensure beryllium contamination is controlled



Surface contamination (removable)

- Controlled areas are regularly monitored for surface beryllium contamination by wet swipe sampling (NIOSH 7300)
- Diagnostics are swipe sampled after cleaning to ensure effective decontamination before release to general areas

Airborne contamination

- Personal monitoring devices are worn during target chamber entry
- Stationary airborne sampling is conducted in select areas to estimate the 8-hr (TWA) exposure

NIOSH 7300 - <http://www.cdc.gov/niosh/docs/2003-154/pdfs/7300.pdf>

Airborne sampling to date has shown no detectable airborne beryllium particulates in any unregulated LLE area

LLEINST 6706 identifies the minimum monitoring requirements for areas at LLE where beryllium is used, handled, or stored



Area	Classification	Minimum monitoring requirements	
		Airborne	Surface
Target Chambers (OMEGA & OMEGA EP)	Regulated	Semi-annual	Semi-annual
Beryllium Workstations (BWS)	Operational	N.A.	Semi-annual [†]
LaCave	General	Annual*	Semi-annual
OMEGA EP Grating Compression Chamber (GCC)			
Target Fabrication	General	One-time baseline	Semi-annual
X-Ray Laboratory			
* Additional airborne monitoring to be conducted if surface swipe sampling detects beryllium above the ASCL [Table 1, Sec. 4(a)]			
† Work surfaces only			

All work and decontamination of diagnostics is to be performed in the Beryllium Workstations (BWS)

Beryllium Workstations are located in OMEGA, OMEGA EP, the Diagnostics Workshop (Rm 6106), and LaCave

- Unless there is a compelling reason (approved by the Chemical Safety Officer), all Beryllium work, including wet-crimp cutting, is to be performed in a BWS (e.g., an exception is granted to LLE Target Fab operations)
- BWS users must read and follow the Beryllium Workstation Procedures Manual (S-SA-M-040)
- It is the user's responsibility to ensure that the inner surfaces of the workstation have been thoroughly decontaminated of beryllium particulates and that all items are removed from the workstation.*



Removable one-piece work surface and “radiused” corners simplifies cleaning

The BWS are NOT to be used for storage of beryllium or beryllium-containing/beryllium contaminated items

Beryllium exposures are best prevented by the same methods used for other hazardous materials

Engineering controls

- Handling, storage, processing, decontamination and transport of beryllium and beryllium-containing items is conducted in enclosures or particle-filtered workstations
- Order beryllium cut to size



Rm 6106 (Diagnostic Workshop) - Contact: G. Pien 275-5848

Beryllium exposures are best prevented by the same methods used for other hazardous materials (cont.)



Safe Work Practices

- Only shape by wet crimp cutting
- Work on (potentially) Be-contaminated items **ONLY** in Beryllium workstations
- Minimize storage in work areas
- Keep work area clean and organized – (Housekeeping)
- Never clean Be while under vacuum/pressure
- Employee safety training



Personal Protective Equipment (PPE)

- Impact resistant eyewear, disposable latex or nitrile gloves, and a laboratory coat or gown with elasticized cuffs are required
- Half-mask respirators with N100 filter are required in regulated areas and for certain specific operations (i.e. removing lower pylon cover)



The OMEGA and OMEGA EP target chambers are beryllium-regulated areas and require respiratory protection for entry



- All respirator users must be enrolled in the UR Respirator Wearers Program (UHS) and be certified on an annual basis

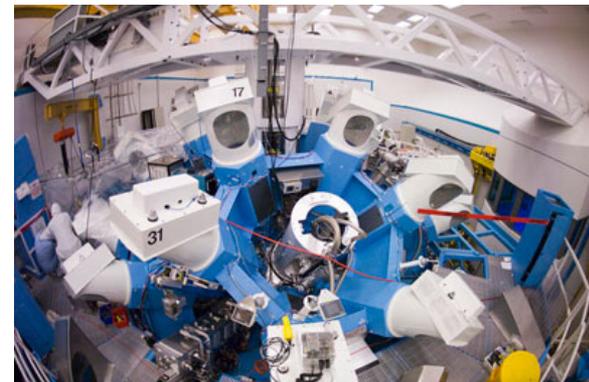
Initial Certification

- Medical history form
- Medical exam
- Spirometry test
- Respirator fit test



Annual Recertification

- Verify medical history
- Respirator fit test



Procurement of beryllium at LLE is strictly controlled



- The Mechanical Engineering Production Control Specialist is the **ONLY** person at LLE authorized to purchase beryllium
- Definition: **Article** - cut-to-size, ready to use. Articles are generally individually packaged.
- Personnel who use beryllium shall only store quantities of beryllium in their laboratories or work areas that are deemed sufficient for short-term needs.

Whenever practical, beryllium is to be purchased in article form

The Beryllium Management System (BMS) has been developed to track and manage LLE's beryllium inventory



All beryllium will be kept in the Central Repository (Rm 6106)

- Beryllium is to be signed-out *only* as needed
 - It should **NOT** be stored long-term in other areas

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Inventory Transfer Receive FindArticle Personnel

Beryllium Tracking Database

Select a Report and 'Go'.

Location Inventory

Article Inventory

To find an article select [Find Article](#) here.

Article	PDM	Thick.	Width	Len.	CAS	Location	Storage Area	Quantity
1000	D-XE-C-040	.008"	8"		7440-41-7	6106	Be Drawer	24
1001	D-XE-C-040	.02"	8"		7440-41-7	6106	Be Drawer	36
1002	D-XE-C-042	.004"	1.026"		7440-41-7	6106	Be Drawer	37
1003	D-XE-S-009	.00078"	5"		7440-41-7	6106	Be Drawer	50
1004	D-XE-S-009	.004"	5"		7440-41-7	6106	Be Drawer	153
1005	D-XE-S-009	.0078"	5"		7440-41-7	6106	Be Drawer	9
1006	D-XE-S-009	.008"	5"		7440-41-7	6106	Be Drawer	61
1007	D-XE-S-009	.01"	5"		7440-41-7	6106	Be Drawer	111
1008	D-XE-S-009	.02"	5"		7440-41-7	6106	Be Drawer	111

Beryllium use and storage is limited to preapproved areas within LLE (Rm 146, 247, 1228, 2828, 6106)

All movement of beryllium throughout LLE is to be logged using the BMS



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Inventory **Transfer** Receive FindArticle Personnel

Beryllium Tracking Database Transaction Log

To find an article, select [Find Article](#) here.

To check inventory, select [Check Inventory](#) here.

Article
Quantity
Source
Destination
Comments

Storage Area

Submit

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Inventory Transfer **Receive** FindArticle Personnel

Beryllium Tracking Database Receive Log

To find an article, select [Find Article](#) here.

To check inventory, select [Check Inventory](#) here.

Article
Quantity
Source
Destination
Comments

Storage Area

Submit

Pending Transfers

There are no Pending Transfers.

Beryllium that is no longer in use must be returned to the Central Repository or processed for disposal



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Inventory **Transfer** Receive FindArticle Personnel

Beryllium Tracking Database *Transaction Log*

To find an article, select [Find Article](#) here.

To check inventory, select [Check Inventory](#) here.

Article	<input type="text"/>		
Quantity	<input type="text"/>	Storage Area	
Source	<input type="text"/>	<input type="text"/>	
Destination	<input type="text" value="Disposal"/>	<input type="text"/>	
Comments	<input type="text"/>		
		<input type="button" value="Submit"/>	

The Chemical Safety Co-op will conduct inventory reconciliation every six months

Wet-crimp cutting is the only LLE-approved beryllium-shaping process



- Place material to be cut on absorbent surface (e.g., paper towel)
- Saturate with ethanol
- Cut using crimp or shear tool
- ***Dispose of any shards and paper towels as hazardous chemical waste***

All other beryllium shaping processes are expressly prohibited (e.g., sawing, drilling, abrading, milling, filing, etc.)

Several restrictions apply to handling and using beryllium vacuum windows

- Beryllium windows under a pressure differential are never to be wiped, cleaned, or contacted in any way until the apparatus containing them is **vented** to room pressure
- Protect exposed Be windows from damage during non-use by using a plastic or metal cap
- Mechanical Engineering must review and approve ALL uses of Beryllium as a pressure (vacuum or elevated pressure) boundary (i.e. window)



Cryostats that have a Beryllium pressure boundary must employ a Pressure Relief Device (PRD) to prevent over pressurization during warm-up

Precautions must be taken for storage and transport of beryllium and beryllium-contaminated items within LLE



- Separate storage for new, unused beryllium and used or recycled items (minimizes spread of particulate contamination)
- Only store quantities of beryllium sufficient for immediate needs
- Return unused inventory to the Central Repository (Rm 6106)
- **Store separately from other materials***
- Transport beryllium contaminated diagnostics in secondary containment (i.e. plastic box or bag) within operational areas



Beryllium-containing equipment is not to be released to uncontrolled areas unless the Be contamination is below the ASCL (“Free Release Limit”) of $0.2 \mu\text{g}/100 \text{ cm}^2$

*OSHA Laboratory Carcinogens and Reproductive Agents regulations, 2011

The Beryllium Workstation Procedures Manual identifies proper decontamination procedures for BWS use



- The front air foil and the rear baffle slots must remain unobstructed
- Negative pressure plenum surrounds contaminated positive pressure plenum
- ULPA (Ultra Low Penetration Air) filtration (99.999% removal of particles $\geq 0.12 \mu\text{m}$)

The minimum PPE for working with beryllium is impact resistant eyewear, disposable latex or nitrile rubber gloves, and a laboratory coat or gown with knit/elasticized cuffs.

Containers, storage areas, and equipment containing beryllium must be clearly marked with specific information



New/unused Be:

BERYLLIUM
DANGER!
CANCER AND LUNG DISEASE HAZARD
DO NOT REMOVE DUST BY BLOWING OR SHAKING

¹

Used Be/
Be-contaminated equipment:

DANGER
CONTAMINATED WITH BERYLLIUM
CANCER AND LUNG DISEASE HAZARD
DO NOT REMOVE DUST BY BLOWING OR SHAKING

¹

Diagnostics with Be windows
operated at differential pressure:

CONTAINS BERYLLIUM WINDOW
EXTREMELY BRITTLE-DO NOT TOUCH, CLEAN, OR CONTACT WITH
ANY OBJECT WHILE UNDER VACUUM

Thickness: _____

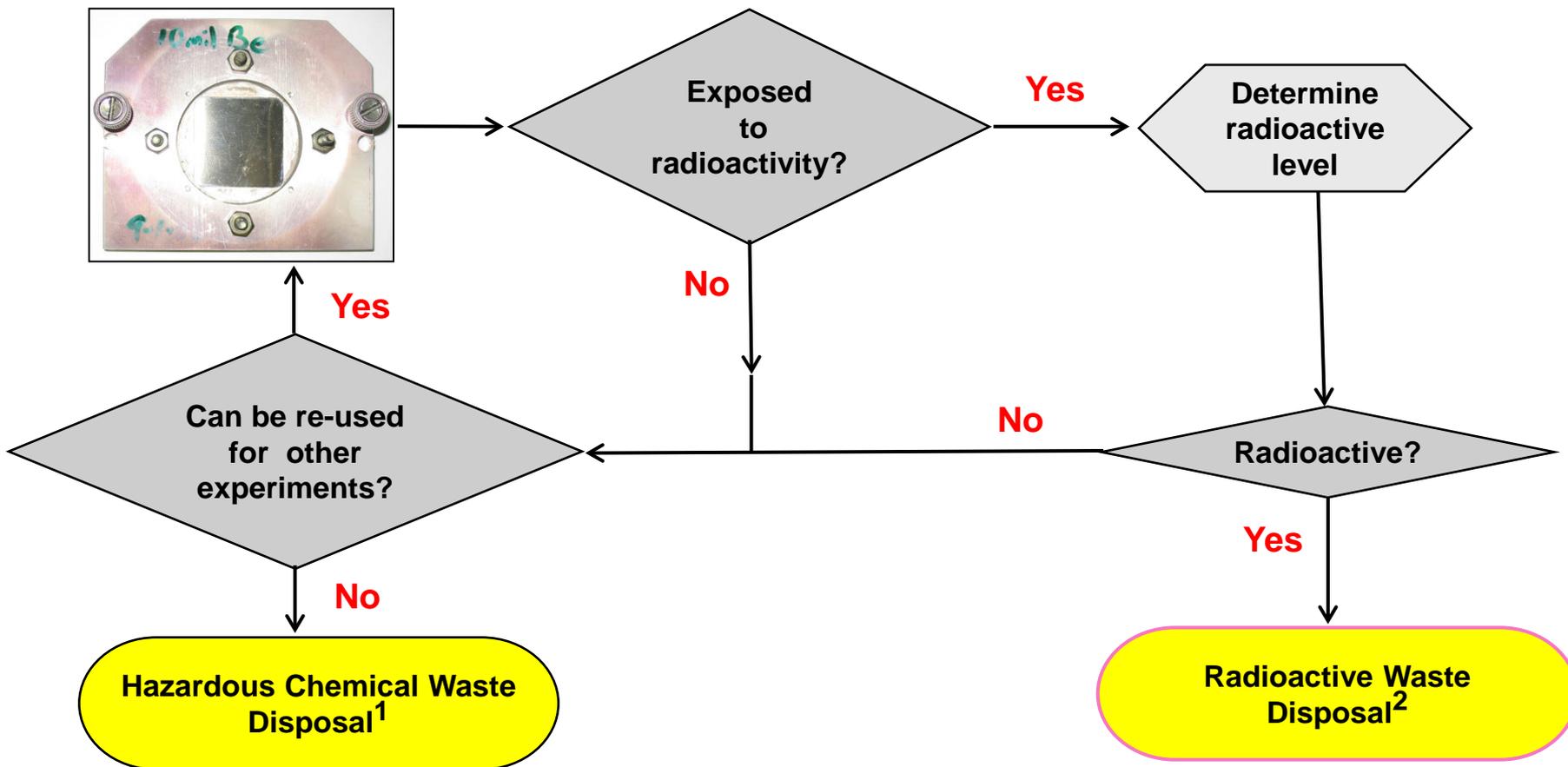
Diameter: _____

²

¹ DOE 10 CFR 850.38

² LLEINST 6706

The proper path for disposal of beryllium depends on its usage history



(1) C 001: "Chemical Safety (http://safety.lle.rochester.edu/520_training/presentations.php)

(2) RadCon Manual – (LLEINST 6610 <http://www.lle.rochester.edu/media/resources/documents/6610.pdf>)

Non-radioactive beryllium is classified as an EPA hazardous waste when it becomes unusable for any experimental activity



- Used Beryllium that can be potentially re-used should be classified and labeled as **“in-process” beryllium**
- In-process beryllium can be stored in operational areas (as defined in LLEINST 6706) indefinitely and are *exempt* from EPA hazardous waste storage and labeling requirements
- Beryllium that cannot be used further is defined as **“beryllium waste”** and is subject to EPA hazardous waste regulations*
 - labeled hazardous waste accumulation area
 - accumulation labels on containers
 - tracking tags at time of disposal

* C 001: “Chemical Safety (http://safety.lle.rochester.edu/520_training/presentations.php)

LLEINST 6706 provides procedures for the disposal of beryllium and beryllium-related wastes



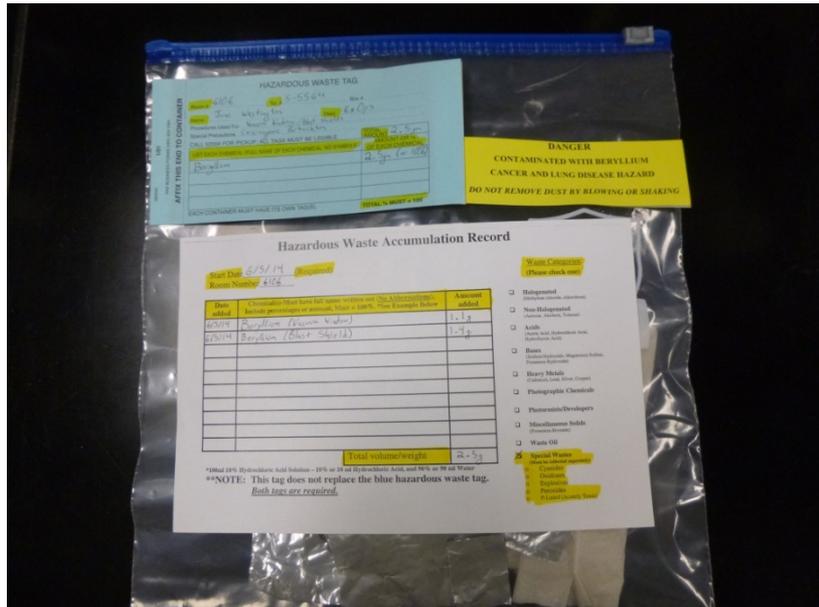
- **Proper disposal of Be waste utilizes either sealed, impermeable bags with a wall thickness ≥ 6 mil or rigid containers that can be tightly sealed**
- **All containers must be labeled in accordance with both LLE 6706 and EPA hazardous waste disposal requirements**
- **Labeled containers of non-radioactive beryllium waste are placed in the LLE Central Hazardous Waste Storage area in the shipping and receiving area for collection by the University's Hazardous Waste Management Unit**
- **Tritium-contaminated beryllium waste is labeled and disposed of as radioactive waste (per LLEINST 6610, section 3011), through the UR Radiation Safety Unit**

Beryllium-contaminated wipes are exempt from this requirement and can be disposed of in the regular trash.

Improperly-contained and labeled non-radioactive beryllium waste will be rejected by the UR Hazardous Waste Management Unit

Correct

Incorrect



Always ensure that beryllium waste is properly labeled before disposal

Repeated occupational exposure to beryllium-containing particulates can have serious health consequences



- Health risks from a single-incident exposure to beryllium particles are low and reversible
- ***Repeated*** exposure to low levels of beryllium *particles* is a risk factor for developing *Chronic Beryllium Disease (CBD) and cancer*
- LLEINST 6706 establish procedures and protocols for working safely with beryllium at LLE
- Both airborne and surface beryllium contamination must be tightly controlled to prevent adverse health effects
- Special precautions must be taken in processing, storage and transport of beryllium-contaminated items within LLE
- ***Worker feedback will be used to improve procedures***

Your participation is vital for ensuring the lowest possible level of risk when working with beryllium

You have completed the first step in the C_002 training
– but there is still one more thing.....



Complete the on-line quiz for C_002 and follow instructions when you receive your grade by email.